5.0 MARINE CASUALTIES AND OIL SPILLS

This section examines the potential economic effects of the No Action Alternative resulting from marine causalities and oil spills, in that without dredging, the navigation channels are expected to become shallower, thus affecting the quantity and the severity of marine casualties and oil spills in the Central/Western Study Area.

5.1 Economic Impact of Marine Casualties

Given the risks inherent in maritime activity, even if the Study Area's channels and harbors were maintained at the (2000) controlling depth, there would be a number of marine causalities and damages associated with them over the Study Period. If the channels were not maintained, and shoaled according to the No Action Alternative projections, an increased number of casualties and damages would be expected to occur.

The objective of this section is to examine potential economic costs associated with casualty damages under both the dredging and no dredging scenarios. If damages from marine casualties are higher under the No Action Alternative (no dredging) than under the existing condition (dredging), economic costs will increase. If damages from marine casualties are lower under the No Action Alternative than under the existing condition, economic costs will decrease. Only damages from marine casualties directly associated with the No Action Alternative constitute economic costs for the purpose of this analysis.

5.1.1 Historic Marine Casualties in Study Area

The Long Island Sound has had a good and consistent safety record over the last decade. The U.S. Coast Guard maintains a database with information derived from marine casualty and pollution investigations conducted by U.S. Coast Guard Marine Safety Offices' investigators. The Marine Investigation Mode of the Marine Casualty and Pollution Database (MINMOD) contains the number of allisions, collisions, and groundings, as well as the damage associated with each. Table 5-1 summarizes marine casualties with damages listed in the MINMOD database for the Study Area during the period of 1992 to 2001.

Table 5-1
Study Area Marine Casualties Damages – 1992-2001

Year	Allisions	Collisions	Groundings	Total Casualties	Reported Damages ($,000)
1992	3	1	5	9	229,733
1993	4	0	4	8	38,567
1994	1	1	2	4	804,444
1995	3	2	1	6	59,355
1996	2	1	2	5	46,082
1997	2	1	7	10	112,931
1998	2	1	2	5	64,560
1999	3	3	2	8	233,502
2000	1	0	3	4	41,200
2001	2	0	1	3	3,874
Total	23	10	29	62	1,634,249

Source: MINMOD - Marine Casualty and Pollution Database, the United States Cost Guard, 1992-2001. This safety record was also verified by anecdotal evidence and numerous interviews with ship operators.

The number of casualties per year reported in the MINMOD ranged from three to ten, with an average of 6.2 incidents per year during the 1992 - 2001period. Total marine casualty damages per year ranged from $3,874 to $804,444 with an average damage per year of about $163,425. The average damage per incident over the ten-year period was about $26,359. There were about 0.56 accidents per 10,000 commercial trips. The average damage per commercial trip was $1.49[xxiii]. All monetary values are measured in (2000) dollars.

5.1.2 Estimating Future Damages

It is assumed that the good safety record of Long Island Sound would continue in the future; therefore, under the Existing Condition, it is reasonable to expect that the number of casualties would follow the general patterns observed in the past 10 years.

Under the No Action Alternative, channels would not be dredged for twenty years. The decreases in channel depths and widths, shifts in channel locations, and lack of maintenance could have important impacts on traffic density, vessel interactions, investment in structures and technology, training of port operators, lightering, navigation technology, and other factors with long run implications to navigation safety. This could have a significant impact on the number of casualties and casualty rates.

A cursory examination of Waterborne Commerce data has revealed that over 6.5 thousand trips per year could be impacted by the No Action Alternative. These trips include inbound and outbound trips, based on Waterborne Commerce data for year 2000, that are equal to or are above the practical channel depths predicted for the Study Area in the next 20 years.

Table 5-2 illustrates the number of trips that would be impacted at selected ports, assuming a constant fleet forecast at year 2000 level.

Table 5-2
Analysis of Trips Impacted by Shoaling Under the No Action Alternative

Connecticut Harbors							
Bridgeport Harbor				**New Haven Harbor**			
		Total Trips	**22,217**			**Total Trips**	**3,967**
Year	**Projected Depth**	**Impact (Trips)**	**Impact (% Total)**	**Year**	**Projected Depth**	**Impact (Trips)**	**Impact (% Total)**
2001	35	6	0%	2001	33	40	1%
2005	34	11	0%	2005	30	73	2%
2010	23	117	1%	2010	27	132	3%
2015	22	150	1%	2015	24	204	5%
2020	21	196	1%	2020	20	405	10%
New York Harbors							
Flushing Bay and Creek				**East Chester Creek**			
		Total Trips	**8,239**			**Total Trips**	**3,932**
Year	**Projected Depth**	Impact (Trips)	Impact (% Total)	Year	**Projected Depth**	Impact (Trips)	Impact (% Total)
2001	14	57	0.69%	2001	7	3,146	80%
2005	13	66	0.80%	2005	7	3,146	80%
2010	12	292	3.54%	2010	6	3,932	100%
2015	11	772	9.37%	2015	5	3,932	100%
2020	10	1,337	16.23%	2020	4	3,922	100%

By the end of the Study Period in 2020, about 6% of the current traffic would be directly impacted by the reduction in channel depths predicted under the No Action Alternative. These vessels would have to take advantage of tide conditions and/or lighter their cargo to get to their destinations. For the same amount of cargo to be transported with smaller vessels, traffic density would have to increase. More exposure and traffic density could affect the rate of casualties and damages over time, and thus increase the economic costs of not maintaining these channels.

To estimate the future impact of not dredging, the study team attempted to link the number of casualties that occurred in the past to the shoaling rates observed in the same period. Because the Study Area is composed of various channels that have very different shoaling rates, the approach did not provide an efficient way to estimate casualty rates in the future. Similarly, the study team attempted to link the number of casualties to "years since last dredged," to determine if a disproportionately large number of casualties were occurring on channels that have not been dredged longer. Again, due to the lack of information to deal with the large variability of shoaling rates across different channels, the approach was not used to estimate casualties in the future.

Port operators in the area are greatly concerned that the changes in channel depths and width resulting from the No Action Alternative could have a substantial impact on casualties and oil spills. Although they were not willing to speculate on the number and the severity of marine casualties in the future, they firmly believe that the No Action Alternative will significantly increase the overall risk of accidents and oil spills in the area. This increase in risk would occur due to shallower and narrower channels, shifts in channel contours, channel migration, increased traffic of smaller vessels, increased lightering, and change to more risky behavior such as navigating with lower underkeel clearance, and other factors.

The Delaware River PED Main Channel Study, Vessel Casualty and Oil Spill Analysis[xxiv] prepared by The Greeley-Polhemus Group, Inc., for the U.S. Army Corps of Engineers, Philadelphia District, in 1995 investigated similar concerns about navigation safety. The Philadelphia study concluded that channel improvements there would most likely improve navigation safety. The conclusion was based on an expert knowledge elicitation with pilots and other port operators. In the Delaware study, expert opinion about the relation between channel depth and navigation safety varied considerably "experts have expressed well-supported and legitimate differences of opinion about whether the deeper channel would be safer or not …Some felt the deeper channel would be safer. Others felt it would be more dangerous,… Still others seemed unsure of the net effect of the two opposing safety factors" (Delaware River 1995). The expected economic benefits from the Delaware project improvements were derived using subjective probabilities and simulation models. Some of the reasoning applied by experts to analyze navigation safety at the Delaware channel can also be applied to analyze factors that may impact safety under the No Action Alternative in Central/Western Long Island Sound.

Factors Impacting Marina Casualty Damages

Traffic density: Traffic density increases as more barges and self-propelled vessels may be required to transport the same amount of commodity when channels become shallower and narrower. This increase in traffic density is expected to increase the probability of collisions, groundings, and allisions. An argument can be made that after a certain threshold, when channels become too shallow and inefficient, some operators may move away from water transportation to other modes of transportations, then a decrease in traffic density becomes a very plausible possibility.

Investment in structures and technology: Investment in port facilities and vessels may decrease with the No Action Alternative. As channels on Central/Western Long Island Sound become shallower and less effective, a proportional increase in net investment may cause a less than proportional increase in output, thus increasing average costs and taking away incentives for expansions. Firms may have incentives to extend the life operation of older facilities or/and smaller and older vessels which are not equipped with the most advanced technology to prevent casualties and oil spills. Speculations about future increases in navigation costs due to the No Action Alternative may reduce investments even before channels' depths are impacted. Rational decisions to maximize net present value will take into account transportation opportunities in the future; therefore, expectations about the No Action Alternative may cause shippers to shift their investment to facilities where channels are expected to be maintained regularly. Such actions could impact investment in expansion of docking facilities and reduce the number of jobs in the area, but it could also impact navigation safety.

Training and personal safety measures: Although most port operators recognize the importance of training and personal safety in the long run, rational decisions can be made to postpone training in the short run to reduce operating costs under the No Action Alternative. The skills and abilities of personal as well as their knowledge and awareness of changing channel conditions are also cited as very important safety factors in previous reports.

Underkeel Clearance: Underkeel clearance provides a safety measure against grounding. Over time, as Central/Western Long Island Sound channels shoal, shippers may be pressed to reduce underkeel clearance to maximize trip draft and reduce costs. Reduced underkeel clearance, coupled with other changes resulting from lack of dredging will have important implications to safety

Lightering: With lower channel depths lightering may become an increasingly cost efficient method for delivering petroleum products to Bridgeport and New Haven facilities; therefore, it could be a factor to impact casualties and oil spills in the area. Lightering operations increase the chances of casualties.

The safety record of lightering operations in U.S. waters has been very good in recent years. This safety record is likely to continue, as lightering standards and practices continue to improve. Nevertheless, increasing lightering operations may impact navigation safety indirectly through growing traffic density, as the same cargo is transported with smaller vessels. Increased traffic density will impact the chances of collisions, groundings, and allisions. Moreover, smaller vessels used for lightering purposes may not be as well equipped as larger tankers.

Channel Maintenance: Shoaling can impact both the depth and width of channels, leading to closer interactions and less underkeel clearance, resulting in greater probability of collisions and groundings. Shoaling may also cause unpredictable shifts in the contour of the channels which may also increase navigation hazard.

5.1.3 Methodology to Evaluate Marine Casualty Damages

There are compelling reasons to find that the No Action Alternative will impact traffic density, vessel interactions, investment in structures and technology, training of port operators, and lightering operations. Although the actual magnitude of these impacts on navigation safety and casualty damages is difficult to predict, it is very likely that the number of casualties will increase.

There is substantial uncertainty intrinsic to the analysis, and no statistical or forecasting model can predict with certainty the number of casualties and damages over the next 20 years. A more challenging task is to distinguish the casualties and the damages that will occur as a direct result of the No Action Alternative from those that would occur even if channels were maintained regularly.

Historical information can provide some indication of how many casualties would occur if channels were maintained regularly. The average number of casualties per year during the period 1992-2001 was 6.2, representing a 0.00564% chance that a vessel traveling through the Study Area would get involved in an accident[xxv]. The actual number of casualties per year could be higher or lower, but it would be reasonable to expect, at constant fleet forecast and normal dredging condition, the expected number of casualties in the future would be around 6.2 casualties per year.

If the channels in Central/ Western Long Island were not dredged, there would be a higher probability that a vessel entering Long Island Sound would get involved in an accident. What the new probability would be is uncertain. The true causality rate would depend on many safety factors, some of which were discussed in the previous section and some of which were not. Its true value is not known.

The task of estimating damages from future marine casualties is inherently speculative. Expert opinion from port operators can provide important insights regarding the potential impacts from changing channel structure, investment, risk behavior, and other factors that may affect casualties, but they cannot predict the actual number and their respective damages in the future. Port operators contacted during this analysis were reluctant to provide any subjective judgments about changes in likelihood and magnitude of marine casualties resulting from the No Action Alternative, even as they expressed great concerns about the future of Long Island Sound navigation if channels were not dredged.

Determining the likely impacts on economic costs requires a comparison of casualty damages under the existing condition with the casualty damages under the No Action Alternative. A computer model based on probability distributions was constructed to simulate the pattern of the future number of casualties, the amount of damages, both under the Existing Condition and under the No Action Alternative. The computer simulation randomly selects the number of casualties per year and the average value of damages from each relevant distribution and uses this information to estimate the present value of future damages. This process is repeated two thousand times to identify the central tendency of damages and their expected values. When the computer simulation is completed, the frequency pattern and range of future damages are plotted and analyzed. The same model is then used to compare damages and estimate the economic costs resulting from the No Action Alternative.

5.1.4 Casualty Damages Under the Existing Condition

Under the existing condition, the model assumes that every ship entering or exiting the Central/Western Long Island Sound in the future will have a probability of being involved in an accident that is equal to the historical casualty rate of 0.00564% [xxvi]. This probability will be constant over the Study Period. The expected number of casualties per year will be equal to the total number of trips, times the casualty rate. The number of trips is assumed constant over the Study Period[xxvii]. The actual number of casualties for each year will be based on a binomial probability distribution, where the probability is equal to the historical casualty rate, and the number of trial is equal to the number of trips per year. Each trip can result in only one of two mutually exclusive outcomes – the ship is involved in a casualty or the ship is not involved in casualty. The average damage per casualty is derived from a normal distribution with mean and standard error representing historical values:

Expected casualty damage = number of casualties (uncertain) * average damage (uncertain)

Expected casualty damages under the normal dredging conditions are illustrated by the Cumulative Distribution Function (CDF) in Figure 5-1.

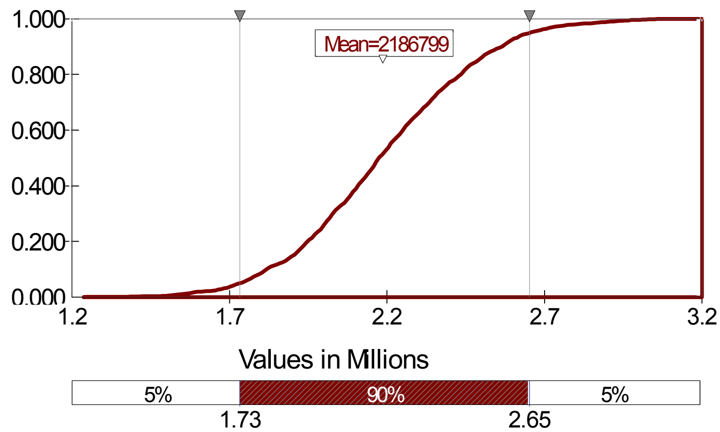

Figure 5-1. CDF for Casualty Damages Under the Existing Condition

The expected accumulated value of casualty damages, under normal dredging conditions, is $2.2 million with a standard deviation of $285,000. There is a 90% chance that the actual value will fall within the range of $1.7 million to $2.7 million.

To estimate the economic costs associated with the No Action Alternative, the expected accumulated value of casualty damages under normal conditions was compared to the expected accumulated value of casualty damages under the No Action Alternative.

5.1.5 Casualty Damages Under the No Action Alternative

Under the No Action Alternative the casualty rates are expected to increase over time. The increases may be the result of channel conditions, investment, training, and other factors that were addressed in the previous sections, or they may be the result of other completely unpredictable factors such as weather, wars, terrorism, etc.

The average damage per casualty could also be impacted by the No Action Alternative. Arguments can be made for both increases and decreases in average damages. On one hand, a disproportional number of larger ships could be affected by decreasing channel depth leading to increased risk of casualties with larger damages. On the other hand, decreasing channel depths may lead to more traffic of smaller vessels or even to less overall traffic, due to shift in mode of transportation, and thus reduce the risk of casualties with large damages. Nothing about the future is certain. For the purpose of this analysis, the expected value of damages is assumed constant at the historical level. Actual damages vary according to a normal distribution with mean and standard error based on historical values.[xxviii]

If "what will happen" is unknown, then an understanding of "what can happen" is useful to determine potential casualty damages and its implications to economics costs. Because the causality rate is a key variable in the determination of potential damages, even if its true value is unknown, knowledge can be gained by evaluating how different casualty rates would impact the overall economic costs in a scenario analysis.

Five scenarios representing changes in casualty rates were created to analyze "what can happen" when the casualty rates change under the No Action Alternative. For each scenario, a computer model simulated the pattern of future number of casualties, the amount of damages, and the overall impact on economic costs. The expected economic cost for each scenario under the No Action Alternative was then compared with the expected economic costs under existing conditions.

The available information does not provide a reliable link between casualty rates and other events predicted under the No Action Alternative; as a result, the scenarios presented in the analysis consider arbitrary changes in casualty rates. Scenario 1 estimates the impact on economic costs if the casualty rate increases by 25% by 2020. The other scenarios consider the impacts on the economic costs if the casualty rates increases by 50%, 75%, 100% and 125%. For a constant number of trips, the number of casualty per year was calculated from a binomial probability distribution, where the probability is equal to the historical casualty rate, and the number of trials is equal to the number of trips per year. The average damage per casualty was derived from a normal distribution with mean and standard error based on historical values. The future value of damages is converted to present value using a 5.875% discount rate. The present value of damages is defined as the accumulated present value of expected damages over the Study Period. The simulation was repeated 2,000 times and the resulting expected number of casualties, expected damages per year, and present value of expected damages for each scenario is presented in Table 5-3.

Table 5-3
Scenarios for Marine Casualty Damages for Selected Years

	2000	**2005**	**2010**	**2015**	**2020**
Scenario 1: Casualty Rate Increases by 25%					
Casualty Rate (per thousand trips)	5.64E-02	5.99E-02	6.34E-02	6.69E-02	7.05E-02
Expected Number of Casualties	6.2	6.6	7.0	7.4	7.8
Expected Damage per Year ($,000s)	183	194	206	217	229
Accumulated Present Value of Damages	**2,402**				
Scenario 2: Casualty Rate Increases by 50%					
Casualty Rate (per thousand trips)	5.64E-02	6.34E-02	7.05E-02	7.75E-02	8.46E-02
Expected Number of Casualties	6.2	7.0	7.8	8.5	9.3
Expected Damage per Year ($,000s)	183	206	229	253	275
Accumulated Present Value of Damages	**2,618**				
Scenario 3: Casualty Rate Increases by 75%					
Casualty Rate (per thousand trips)	5.64E-02	6.69E-02	7.75E-02	8.81E-02	9.87E-02
Expected Number of Casualties	6.2	7.4	8.5	9.7	10.9
Expected Damage per Year ($,000s)	183	217	252	286	320
Accumulated Present Value of Damages	**$2,834,400**				
Scenario 4: Casualty Rate Increases by 100%					
Casualty Rate (per thousand trips)	5.64E-02	7.05E-02	8.46E-02	9.87E-02	1.13E-01
Expected Number of Casualties	6.2	7.8	9.3	10.9	12.4
Expected Damage per Year ($,000s)	183	229	275	320	366
Accumulated Present Value of Damages	**3,051**				
Scenario 5: Casualty Rate Increases by 125%					
Casualty Rate (per thousand trips)	5.64E-02	7.40E-02	9.16E-02	1.09E-01	1.27E-01
Expected Number of Casualties	6.2	8.1	10.1	12.0	14.0
Expected Damage per Year ($,000s)	183	240	297	355	412
Accumulated Present Value of Damages	**3,267**				

5.1.6 Analysis of Economic Costs

The economic costs associated with casualty damages are estimated by subtracting the accumulated present value of damages under the No Action Alternative from accumulated present value of damages under the existing condition. A statistical summary of the results is presented in Table 5-4. A histogram and a cumulative distribution function illustrating the frequency patterns of economic costs for each scenario are provided in Addendum B.

Table 5-4
Economic Costs Associated with the No Action Alternative

($,000)	5% Percentile	Expected Value	95% Percentile	Standard Deviation
Scenario 1	152	217	285	40
Scenario 2	329	433	541	63
Scenario 3	506	650	799	89
Scenario 4	676	866	1,058	116
Scenario 5	846	1,083	1,319	143

The simulation model provides a way of estimating the expected economic costs for each scenario; however, it does not determine which scenario is the most likely one. The true impact of casualty damages on economic costs is unknown.

The scenario analysis illustrates “what happens” to economic costs when casualty rates increases. Most likely, the casualty rates will increase if Central/Western Long Island Sound harbors are not dredged. Factors impacting this increase in casualty rates include (but are not necessarily limited to) changes in channel conditions, investment, training, and traffic density.

The scenarios presented in the analysis show expected economic costs ranging from about $216.000 to over $1 million. All five scenarios show increases in economic costs associated with casualty damages, but the increased cost is not expected to surpass $320,000.

Most probably, the No Action Alternative will increase economic costs by less than $1 million. Increases in casualty rates of 120% would be required if expected economic cost were to reach $1 million. Even if the casualty rates double as a result of the No Action Alternative, the expected economic costs would increase by less than $1 million.

In addition to providing a means to estimate the economic impacts for each scenario, the simulation analysis provided a way to analyze the relationship between casualty rates and expected economic costs. An analysis of the simulation results revealed the following relationship between causality rates and expected economic costs.

Regression equation (1) EC= 36 + $8,659*CR

Where, EC is the expected economic costs measured in dollars, and CR is the change in casualty rate measured in percentage change over the Study Period.

Regression equation (1) predicts that for every percent increase in the casualty rate, the expected economics costs from casualty damages increase by $8,600. For instance, the equation predicts that a 100% increase in casualty rate, would result in about $860,000 in economic cost from casualty damages.

Although a targeted telephone survey was initiated, due to many factors, including confidentiality, it was not possible to discuss the result of this analysis with port operators and other navigation experts in the area. Port operators and other experts with experience in Long Island Sound navigation could provide valuable information to determine the casualty rate in the future. If the casualty rate were determined, then the expected impact of marine casualties on economic costs could be calculated using regression equation (1) described above. Interview with port operations professionals could also provide information to determine the impact of the No Action Alternative on the average damage per casualty, timing of the changes, and on other factors that are required to estimate future damages with greater precision.

5.2 Oil Spills

There will be an unknown number of oil spills in the Study Area over the next 20 years irrespective of whether the circumstances anticipated in the No Action Alternative will occur. That said, the number and the size of the spills may or may not be related to the amount of dredging that will occur in that area.

Under the No Action Alternative, Federal and large non-Federal facilities will not be dredged, thus causing potential impacts to navigation safety. Over time, shoaling would reduce underkeel clearance, accordingly reduce the margin of safety and possibly increase the number of groundings, which could result in more oil spills. Shoaling could also increase lightering operations and traffic density, thus increasing both the number of vessel interactions and the potential for collisions involving spills. Not dredging Long Island Sound would make navigation channels shallower and narrower, shift channel contours, and impact other factors with potential implications to casualty involvement oil spills.

A previous study on casualties and oil spills for the Delaware River[xxix] included a number of interviews and organized plenary sections with navigation experts to determine the impact of dredging on casualties and oil spills. There was no consensus among the experts about the effect of dredging on safety, but their legitimate and well-reasoned differences provide insights about possible factors affecting the number and severity of oil spills incidents in Long Island Sound. For instance, experts agreed that increased underkeel clearance provides an increased margin of safety and would reduce the number of groundings; however, some experts made the argument that shoaling or dredging does not impact underkeel clearance in a practical, marine safety, sense. They asserted that vessels will always load up to take maximum advantage of the available depth, and in case of shoaling, they also will load down to attain a safe underkeel clearance level.[xxx]

Another factor relevant to oil spillage is traffic density. As channels in New Haven and Bridgeport become shallower there will be an increasing need for lightering. Even if the lightering operations themselves are safe, they will increase the number of barges and smaller vessels in the Study Area, thus creating an increased potential for collisions and other incidents. In addition, many barges and other smaller vessels may not be equipped with the same technology available in larger vessels (such as double-hulling), thus increasing the potential risk for casualties involving oil spills.

As discussed in the previous section, the number of casualties will most probably increase as a result of the No Action Alternative. The increase in casualties may also lead to an increase in the amount of oil spilled. Additionally, oil spills could occur as a result of factors not directly associated with casualties, such as valve failures, tank overflows, and hose ruptures, and others.

There are no mathematic or statistical models that can be used to predict with certainty the amount and/or the size of oil spills that will occur in the Study Area during the next 20 years. Even if the amount of oil spilled in the area were predictable, it would be difficult to determine the proportion of it that occurred as result of the No Action Alternative. Understandably, petroleum operators consulted by telephone were reluctant to make any subjective judgment about possible oil spills in the future.

Historic information on the number and the size of spills in the Study Area was retrieved from MINMOD. Table 5-5 summarizes oil-related pollution incidents due to oil and other petroleum related spillage in the water for the years 1992-2001. Pollution incidents without a reported volume of spillage in the water or which were listed as "zero" or "null" as the amount of oil and other petroleum product spilled were not included.

Table 5-5
Oil Spills in the Study Area – 1992 - 2001

Year	Number of Incidents	Total Spill (Gallons)
1992	25	5,125
1993	26	830
1994	31	880
1995	13	104
1996	14	5,545
1997	2	50
1998	4	12
1999	11	1,784
2000	14	342
2001	8	801

Source: The Marine Investigation Mode (MINMOD) of the Marine Casualty and Pollution Database, the United States Coast Guard, 1992-2001.

The average size of a spill for the period of 1992-2001 was about 104.5 gallons[xxxi]. Only two incidents involved oil spills over four thousand gallons: One of those incidents occurred in 1992 (4,400 gallons of oil diesel) at Oyster Bay; the other occurred in 1996 (4,415 fuel oil) at Hart Island. On average, there were about 15 incidents per year involving oil spills. The average amount of oil spilled per year was 1,547 gallons.

5.2.1 Determining Oil Spills in the Future

The oil spill model's logic is similar to that of the marine casualty damage model. Historical information is used to determine the spill rate under the existing condition. The expected spill rates in the future vary according to different scenarios. Actual spill rates are uncertain; therefore, they are derived from a normal distribution with mean standard error equal to the mean and standard error observed during 1992-2001. The total amount of oil spilled in a year is calculated by multiplying the oil spill rate (an uncertain variable) by the petroleum product transported in that year. Petroleum cargo for the Study Area is assumed constant over the Study Period. The process is repeated two thousand times. Table 5-6 presents the basic structure of the oil spill model.

Table 5-6
Long Island Sound Oil Spill Analysis under Existing Conditions

	2000	2005	2010	2015	2020
Existing Conditions					
Oil spill ratio (gallons per thousand tons)	1.1E-01	1.1E-01	1.1E-01	1.1E-01	1.1E-01
Expected Number of Gallons Spilled per Year	1,588.0	1,588.0	1,588.0	1,588.0	1,588.0
Expected Accumulated Spill (gallons)	33,349				

Under existing conditions, it is expected that over 33,000 gallons of oil will be spilled in Long Island Sound during the next 20 years. If the harbors in Central/Western Long Island Sound were not dredged, this amount would be expected to increase. The exact amount of increase in not known. Five scenarios were constructed to illustrate "what happens" or how much oil would be spilled if the spill rate increased by 25%, 50%, 75%, 100%, and 125% from its present level. To provide a complete picture of frequency pattern of future oil spilled, a simulation was created and a simulation process was repeated two thousand times for each scenario, each year.

5.2.2 Oil Spills Associated with the No Action Alternative

To isolate the impact of oil spills resulting from the No Action Alternative, gallons of oil spilled (the Existing Condition) are subtracted from gallons of oil spilled predicted in each scenario under the No Action alternative. The process was repeated for each of the two thousand simulation runs. Values for each year were added to determine the cumulative amount of oil spills over the Study Period. Positive values indicate the total amount of oil spilled over the project life, which is expected to increase if Long Island Sound harbors are not dredged. Negative values indicate a decrease. Table 5-7 presents a statistical summary of the oil spilled as a result of the No Action Alternative. Histograms and cumulative distributions of possible outcomes are included in Addendum B.

Table 5-7
Oil Spills Associated with the No Action Alternative

(,000s Gallons)	5% Percentile	Mean	95% Percentile	Standard Deviation
Scenario 1	-2,885	4,170	11,290	4,395
Scenario 2	651	8,340	15,938	4,682
Scenario 3	3,982	12,509	20,776	5,084
Scenario 4	7,690	16,681	25,753	16,681
Scenario 5	11,240	20,849	30,240	5,772

5.2.3 Future Oil Spills Conclusion

Most probably, the amount of oil spilled will increase if the harbors of Central/Western Long Island Sound are not dredged. The five scenarios presented in the analysis predict increases in oil spilled ranging from 4,000 to 21,000 gallons over the next 20 years.

Historically, Long Island Sound has relatively safe harbors. Even if the oil spill rate doubles in the next 20 years, the actual amount of oil spilled associated with the No Action Alternative would be less than 17,000 gallons.

The potential environmental costs associated with the increase in oil spills were not considered in the analysis.

6.0 FINDINGS AND CONCLUSIONS

This section summarizes the analysis work that was done here and the impacts of the No Action Alternative that were identified. The key areas of interest are:

- Effects of shoaling on harbors in the Central/Western portion of Long Island Sound over the period 2000-2020;

- Commercial shipping and the impacts of shoaling to navigation-dependent industries (Gross State Product (GSP) losses;
- Impacts to recreational boating and freight transportation (income losses);
- Impacts to income, employment and state and local tax revenues from lost business;
- The risks that are associated with changes that will take place primarily in deep draft harbors where lightering, accident and oil spills may occur.

This section puts these issues into perspective by comparing the impacts of this navigation-dependent sector of the regional economy to estimates of state economy activities.

The effects on regional development and growth of the reduced use of harbors, marinas and supporting businesses are also addressed. Although this study evaluated increased shoaling impacts on harbors over twenty years, against the year 2001 economies of the navigation-dependent industries, study findings are probably sufficient for some generalized conclusions.

Finally, because of the importance of port-specific impacts to commercial businesses, Executive Order 12898 requirements were investigated to determine the impacts of economic changes to minorities and low-income residents of the area.

6.1 Shoaling Impacts

Shoaling will likely impact 21 Study Area harbors (Table 6-1):

Table 6-1
Study Area Harbors That May Be Adversely Affected By Shoaling

Harbor	State
Black Rock	CT
Branford	CT
Bridgeport Main Channels	CT
Clinton	CT
Greenwich	CT
Guilford	CT
Housatonic River	CT
Mianus River	CT
Milford	CT
New Haven	CT
Norwalk	CT
Stamford	CT
Stony Creek	CT
West River	CT
East Chester Creek	NY
Flushing Bay and Creek	NY
Mt. Sinai	NY
Mamaroneck	NY
Mattituck	NY
Milton	NY
Port Chester	NY
Westchester Creek	NY

The screening process identified nineteen harbors that would have no adverse impacts (Table 6-2).

Table 6-2
Study Area Harbors With No Adverse Impacts

Connecticut	New York	
Five Mile River	Astoria	Manhasset Bay
Southport	Bronx River	New Rochelle
Westcott Cove	College Point	Northport
	Echo Bay	Oyster Bay
	Glen Cove	Port Jefferson
	Hempstead	Port Washington
	Huntington	Smithtown
	Kings Point	

Table 6-3 shows five-year time frames over the twenty-year Study Period indicating when harbors will be affected by shoaling. This table shows that two-thirds of the harbors are in Central Connecticut and that eleven of these harbors are immediately (2000-2005) impacted as shoaling decreases channel depths.

Table 6-3
Study Area Harbors That May be Adversely Impacted by the No Action Alternative
(Shading Indicates When Shoaling Will Restrict Maritime Activity - by Study Period Intervals)

Harbor	State	2000-05	2005-10	2010-15	2015-20
Black Rock	CT				
Branford	CT				
Bridgeport Main Channels	CT				
Clinton	CT				
Greenwich	CT				
Guilford	CT				
Housatonic River	CT				
Mianus River	CT				
Milford	CT				
New Haven	CT				
Norwalk	CT				
Stamford	CT				
Stony Creek	CT				
West River	CT				
East Chester Creek	NY				
Flushing Bay and Creek	NY				
Mt. Sinai	NY				
Mamaroneck	NY				
Mattituck	NY				
Milton	NY				
Port Chester	NY				
Westchester Creek	NY				

In New York, however, only seven of the harbors in the Central/Western portion of Long Island Sound Study Area are impacted, and three are impacted immediately.

6.1.1 Economic Gross State Product Impacts

Gross state product (GSP) is the economic measure of production or output. Shoaling's annual effects on GSP relating to harbor activity are summarized in Table 6-4.

Table 6-4
GSP Economic Impact (Value Lost) by County/Area
No Action Alternative
2020

Gross State Product ($,000s)						Sales & Income (Non-GSP)= ($,000s)	
County / Area	**Comm. Fishing**	**Boat Building & Marinas**	**Pass. Trans.**	**Freight Trans.**	**Total**	**Recreation**	**Freight Trans.**
Central CT	44,083	145,619	0	0	189,702	6,203	7,061.6
Fairfield CT	4,396	14,521	0	0	18,917	619	3,099.9
Westchester NY	3,622	11,964	0	60,568	76,154	510	0
Bronx/Queens NY	0	0	0	0	0	0	862.6
Nassau NY	0	0	0	0	0	0	0
Suffolk NY	23,911	78,987	0	0	102,898	3,365	0
Total	76,011	251,091	0	60,568	387,671	10,696	11,024.3

Note: Totals may not add due to rounding.

Table 6-4 shows the loss of GSP to the Central/Western Long Island Sound region. About $388 million in GSP could be lost under the No Action Alternative. An additional $10.7 million in sales/income losses will come from recreation, and over $11 million in loss from freight transportation. Table 6-5 provides a detailed breakdown of these values for all affected projects by County/Area.

Table 6-5
GSP Economic Impact (Value Lost) by Project or County/Area
No Action Alternative
2020

Gross State Product ($,000s)						Sales & Income (Non-GSP) ($,000s)	
Project or County / Area	**Comm. Fishing**	**Boat Building & Marinas**	**Pass. Trans.**	**Freight Trans.**	**Total**	**Recreation**	**Freight Trans.**
Clinton Harbor	21,620	71,418	0	0	93,038	3,042	0
Guilford Harbor	6,527	21,562	0	0	28,089	918	0
Stony Creek	1,092	3,608	0	0	4,700	154	0
Branford Harbor	13,401	44,268	0	0	57,669	1,886	0
New Haven Harbor	0	0	0	0	0	0	7,061.6
West River	617	2,039	0	0	2,656	87	0
Milford Harbor	825	2,724	0	0	3,549	116	0

Table 6-5
GSP Economic Impact (Value Lost) by Project or County/Area
No Action Alternative
2020

Project or County / Area	Gross State Product ($,000s)					Sales & Income (Non-GSP) ($,000s)	
	Comm. Fishing	Boat Building & Marinas	Pass. Trans.	Freight Trans.	Total	Recreation	Freight Trans.
Central CT	**44,083**	**145,619**	**0**	**0**	**189,701**	**6,203**	**7,061.6**
Housatonic River	0	0	0	0	0	0	10.5
Bridgeport Harbor	0	0	0	0	0	0	2,577.0
Norwalk Harbor	0	0	0	0	0	0	115.7
Stamford Harbor	0	0	0	0	0	0	396.9
Mianus River (Cos Cob Harbor)	4,396	14,521	0	0	18,917	619	0
Greenwich Harbor			0	0	0	0	0
Fairfield CT	**4,396**	**14,521**	**0**	**0**	**18,917**	**619**	**3,099.9**
Mamaroneck Hrbr	3,571	11,797	0	0	15,368	503	0
Westchester Creek	51	167	0	0	218	7	0
East Chester	0	0	0	60,568	60,568	0	0
Westchester NY	**3,622**	**11,964**	**0**	**60,568**	**76,154**	**510**	0
Flushing Creek	0	0	0	0	0	0	862.6
Bronx/Queens NY	**0**	**0**	**0**	**0**	**0**	**0**	**862.6**
Nassau NY	0	0	0	0	0	0	0
Mattituck Harbor	1,066	3,520	0	0	4,586	150	0
Northport Harbor	1,199	3,960	0	0	5,159	169	0
Glenn Cove Creek	4,263	14,081	0	0	18,344	600	0
Mt. Sinai	17,384	57,425	0	0	74,809	2,446	0
Suffolk NY	**23,911**	**78,987**	**0**	**0**	**102,898**	**3,365**	0
Total	**76,011**	**251,091**	**0**	**60,568**	**387,671**	**10,696**	**11,024.3**

Note: Totals may not add due to rounding.

6.1.2 Harbor Impacts vs. State and Regional Impacts

Tables 3-3, Annual GSP Value of Connecticut Study Area Harbors, and Table 3-28, Annual GSP Value of New York Area Harbors, describe the economic contribution to gross state product (GSP) generated by the harbors in the Central/Western Long Island Sound. Approximately $4.5 billion of GSP (economic output) of the states of New York and Connecticut is directly linked to Study Area harbors and channels through the various navigation-dependent industries that operate there. Table 6-6 identifies the harbors in the Central/Western Long Island Sound region that contribute significantly to the region's navigation-dependent industries. The table shows the estimated contribution to gross state product for each harbor.

Table 6-6
Major Contributors to Central/Western LIS Economic Activity

Major Harbors in Central/Western LIS	GSP ($,000s)
New Haven Harbor, CT	574,479
Bridgeport Harbor, CT	344,684
Port Jefferson Harbor, NY	267,911
Huntington Harbor, NY	101,866
Flushing Bay Harbor, NY	137,985
Hempstead Harbor, NY	100,464
East Chester Bay, NY	111,898

All of these, except East Chester Bay, are Federal projects that rely on the Corps of Engineers for dredging. Each harbor in Table 6-6 produced more than $100 million in gross state product in 2001. For these harbors, the navigation-related contribution to GSP is over $1.6 billion, which is more than half of the total navigation-related GSP for the Study Area of $3 billion.The navigation-dependent industries that produce these outputs are in fourteen Standard Industrial Classification (SIC) Codes (described previously), used in the ENSR 2001a report, which include Commercial Fishing, Ship Building and Repair, Deep Sea Transportation of Freight, Water Transportation Freight, Water Transportation of Passengers, Marine Cargo Handling, Towing and Tugboat Services, Marinas and Water Transportation (not included elsewhere). These SIC codes represent a small slice of the overall economy of the region, that is described by 528 economic sectors (basis of ENSR 2001a report), and generated GSP. Table 6-7 shows the gross state product for Connecticut and New York in 2001.

Table 6-7
Connecticut and New York State Gross State Product (2001)
($ Millions)

	Connecticut ($ Millions)	New York ($ Millions)	Total ($ Millions)
Gross State Product	165,632.5	817,017.5	982,650.0

Ref: Telephone information from Global Insights, Inc.

The contribution to GSP from the navigation-dependent industries in the Study Area of $3 billion represents less than 1% of the total GSP for the two-state area. However, impacts of navigation-related economic activity at the local level, to local economies around a specific harbor, can be much more significant than this figure would suggest.

6.2. Changes in Socio-economics of the Region

For each county in the Study Area, the total values of income and the contribution to GSP were obtained for 2001. Income from navigation related industries is assumed to be the same as generated on average as for the entire economy for each county. The data for Bronx and Queens counties were combined to correspond with that county/area used to sum impacts throughout the report. Data for Central Connecticut are based on totals for Middlesex and New Haven Counties.

The value of tax revenues includes state and local government receipts for income and sales taxes. Tax rates vary more by state than by county. The tax revenues are estimated to represent 10.2% of GSP generated in Connecticut and 22% of GSP generated in New York. These estimates are based on the GSP and tax revenues developed for the ENSR, 2001a study.

Employment associated with GSP is also based on the state-by-state estimates developed for ENSR, 2001a. Each job is associated with $114,277 of GSP in NY and $103,701 in Connecticut.

Table 6-8 displays the economic value of navigation dependent industries in the Study Area, as calculated by GPC, by county and state. These industries annually account for almost 28,000 jobs through the direct, indirect and induced impacts. These workers produce almost $3 billion in GSP and earn about $1.8 billion in personal income.

Table 6-8
Economic Value of Navigation Dependent Industries
Central/Western LIS

		Personal		
	GSP	**Income**	**Employment**	**Taxes**
County/Area	**($000's)**	**($000's)**	**(jobs)**	**($000's)**
Central CT	809,339	408,784	7,805	82,773
Fairfield Co.	740,610	506,813	7,142	75,744
Westchester Co.	237,133	173,559	2,075	52,249
Bronx/Queens	276,626	204,790	2,668	28,291
Nassau Co.	224,719	138,767	1,966	49,514
Suffolk Co.	692,209	348,122	6,057	152,518
Total	2,980,636	1,780,833	27,713	441,089
CT	1,549,948	915,597	14,946	158,517
NY	1,430,688	865,237	12,766	282,572

Ref: GPG Calculation

6.2.1 Income

The losses to annual income are expected to increase rather sharply from nearly $33 million in 2005 to over $216 million in 2020. These losses represent the direct, indirect and induced impacts of shoaling on the navigation-dependent industries.

6.2.2 Employment

Shoaling will affect annual employment losses gradually from 1,249 at first in 2005 to over 7,600 by 2020. These losses will complement the income losses, and, together, will produce additional impacts to tax revenues.

6.2.3 Tax Revenues

Tax revenue losses are likely to increase from nearly $4 million in 2005 to nearly $28 million in 2020. Tax revenues are affected by direct, indirect and induced effects of channel shoaling.

6.3 Effects On Development and Resource Usage

Based on 2000 Census data, the civilian labor force in the Study Area was 1.9 million in 1999. For 2020, with a loss of employment of 7,600, this represents about a 4% increase in unemployment. When the surrounding civilian labor force is considered in counties where these communities are located, the impact is a fraction of a percent.

These losses, in light of the enormous economy in the Central/Western Long Island Sound region, of which navigation-dependent industries are a small factor (and given that the multiplier effects—the interaction among businesses—have been included in this analysis), will have minimal impact on growth and development.

The most significant impacts are projected to occur in the Central Connecticut area. If the concentration of unemployment is centered in the communities affected by immediate shoaling impacts, the rate of unemployment could be much higher and affect development and growth.

6.4 Environmental Justice

Executive Order 12898 “Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Population,” (1994) provides that "each Federal agency shall make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high adverse human health or environmental effects of its programs, policies and activities on minority populations and low-income populations." Since this study focuses on the economic impacts of reduced dredging and the effects of shoaling on deep draft navigation and recreational boating, Environmental Justice impacts would occur if recreational boating by low-income and minorities were disproportionately impacted, or if deep draft navigation impacts (mostly oil transport in this case) were to disproportionately affect these groups.

As discussed above, shoaling of ports and harbors will have direct economic impacts on businesses that rely on deep channels for transport of raw materials and supplies, as well as on businesses that support recreational activities. These impacts will cause suppliers' costs to rise and force decisions that will divert supplies to other routes. Some of the direct suppliers will be affected severely, and their businesses will fail. Others will adjust and pass on the additional costs to customers. In either case, customers will face increasing costs, if shoaling limits access to ports and harbors. Cost-driven economic consequences would tend to most particularly affect low-income groups and minorities with limited abilities to pay.

Recreational impacts will be borne primarily by higher income owners of large powerboats and deep draft sailing vessels.

Disrupted commercial businesses will mostly be affected by re-routing of supply routes. Price increases will be minimal because of competition among sellers. Heating oil, however, may be affected and low-income buyers could see significant price increases. However, these costs are already a concern to various agencies in the Northeast where low-income assistance programs are in effect to keep consumer oil available to low income families.

[i] Scope of Work - Economic Analysis - Task 43, Long Island Sound Dredged Material Disposal Site Designation EIS, Battelle Memorial Institute, for the U.S. Army Corps of Engineers, 2002. ("Task 43 Scope"), p. 1.
[ii] The particular studies of relevance for this report are *Economic Significance of Navigation Dependent Industries*, Long Island Sound Dredged Material Disposal EIS. Prepared under Contract No. DACW33-96-D-0004, Task Order 25, Mod. 18. Document No. Long Island Sound-2001-A09-E. October 2001. 20 pp + Appendices ("ENSR, 2001a"); and *Dredging Needs Navigation-Dependent Facilities*, Long Island Sound Dredged Material Disposal EIS. Prepared under Contract No. DACW33-96-D-0004, Task Order 25, Mod. 14. Document No. Long Island Sound-2001-SO8-E. October 2001. 25 pp + Appendices ("ENSR, 2001b").
[iii] ENSR, 2001a, p. 2.1.
[iv] http://education.usace.army.mil/navigation/glossary1.html
[vi] In the interest of brevity, the term "harbor" in this report is intended to refer to all waterways, inclusive of rivers, channels, anchorages, berths and similar sites.
[vii] WCUS1, p. iv.
[viii] WCUS1, p. iii.
[ix] Controlling depth information for Port Chester and East Chester Creek from NAN; controlling depth information for New Rochelle, Westchester Creek, Bronx River, Flushing Bay and Creek, Manhasset Bay, Hempstead, Glen Cove and Port Jefferson from NAE. Vessel draft information from U.S. Army Corps of Engineers, 2000. Waterborne Commerce of the United States, Part 1 – Waterways and Harbors - Atlantic Coast, Institute for Water Resources ("2000 Waterborne Commerce").
[x] WCUS1, P. 231.
[xi] WCUS1, P. 26.
[xii] Channel descriptions from WCUS1, p. 26.
[xiii] WCUS1, P. 26.
[xiv] http://connecticut.boatmarinas.net/
[xv] WCUS1, P. 26.
[xvi] WCUS1, P. 26.
[xvii] WCUS1, P. 26.
[xviii] WCUS1, P. 26.
[xix] WCUS1, P. 26.
[xx] Embassy Guide, 8th Edition.
[xxi] U.S. Army Corps of Engineers, 1981. Draft Programmatic Environmental Impact Statement for the Disposal of Dredged Material in the Long Island Region, prepared by U.S. Army Corps of Engineers, New England Division.
[xxii] State of New York, Department of Motor Vehicles. Information provided by the State of New York as to total registrations, 531,408, varies slightly (less than .32%) from the state-reported 529,724 registrations broken down by length.
[xxiii] The value is calculated dividing the average damage per year for the period of 1992-2001 by the number of inbound and outbound trips listed in the Waterborne Commerce for the year 2000.
[xxiv] Delaware River PED Main Channel Study, Vessel Casualty and Oil Spill Analysis, Prepared for the U.S. Corps of Engineers, Philadelphia District, 1995 (Delaware River 1995).
[xxv] This ratio is based on commercial trips for 2000 reported in WCUS1
[xxvi] This probability was calculated by dividing the average number of casualties per year during the period 1992-2001 by the number of commercial trips reported in the Waterborne Commerce for year 2000.
[xxvii] For the purpose of this analysis, the fleet is assumed constant during the Study Period.
[xxviii] The normal distribution has a mean and standard error based on casualties reported in the MINMOD for the years 1991-2001. The normal distribution was truncated at zero to avoid negative damages.
[xxix] Delaware River 1995.
[xxx] While such analysis may be applicable to the economic consequences related to accidents, it should not be confused with the economic impact of vessels carrying smaller volumes of product, with concomitant effects on industries' benefit-cost calculations.
[xxxi] This average is calculated by dividing the total number of gallons spilled in the 10 year period by the total number of incidents during the same period of time.